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PROPERTIES AND USES OF THE SOUTHERN PINES.

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CONTENTS.

Page.

Introduction 5
  Names 5
  Botanical description 6
  Distribution 7
  Enemies 7
Physical properties 8
  Appearance and characteristics of wood 8
  Shrinkage 9
  Kiln-drying 10
Mechanical properties 11
  Structural material 11
    Method of testing 11
    Strength and stiffness of large beams 13
    Grading 13
    Effect of seasoning 16
    Effect of knots 18
    Effect of rate of growth 21
  Small pieces 21
    Kinds of tests 21
    Relative strength of large and small pieces 22
    Effect of moisture 24
    Effect of rate of growth 25
    Effect of weight 26
    Effect of age and height in tree 26
    Effect of "boxing" 27
Utilization 28

ILLUSTRATIONS.

Page.

Fig. 1. Method of testing a bridge stringer in bending 12
2. Distribution of moisture in cross section midway of the length of North Carolina pine beams 16
3. Relation between moisture and bending strength for loblolly pine 24
4. Relation between rate of growth and crushing strength for loblolly and shortleaf pine 25
5. Relation between weight and crushing strength for longleaf, shortleaf, and loblolly pine 26
6. Variation of weight with height in tree 27

PROPERTIES AND USES OF THE SOUTHERN PINES.[a]

INTRODUCTION.

The southern pines, including longleaf, shortleaf, loblolly, and other varieties of minor importance, such as Cuban pine, spruce pine, and pond pine, grow principally in a belt from 200 to 400 miles wide along the Atlantic coast and the Gulf of Mexico, from Virginia to eastern Texas. They furnished in 1907 one-third of the total lumber cut of the United States, approximately 13 billion board feet.

NAMES.

The greatest confusion exists in regard to the common names of the southern pines, not only in the localities where they are lumbered, but also in the lumber markets and among wood users. Thus specifications of architects and builders often call for "southern pine" and allow any or all of the pines in question. To assist in clearing this confusion a list of the botanical and common names of the three principal southern pines is given in Table 1.

TABLE 1.—*Nomenclature of southern pines.*

BOTANICAL AND ACCEPTED COMMON NAMES.

Pinus palustris. Longleaf pine.	Pinus echinata. Shortleaf pine.	Pinus taeda. Loblolly pine.

LOCAL, MARKET, OR LUMBERMEN'S NAMES.

Longleaf pine.	Shortleaf pine.	Loblolly pine.
Southern yellow pine.	Yellow pine (N. C., Va.).	Slash pine (Va., N. C.).
Southern hard pine.	Shortleaved yellow pine.	Cornstalk pine (Va.).
Southern heart pine.	Shortleaved pine.	Loblolly pine (Gulf region).
Southern pitch pine.	Virginia yellow pine.	Oldfield pine (Gulf region).
Hard pine (Miss., La.).	Bull pine (Va.).	Rosemary pine (N. C., Va.).
Heart pine (N. C., and Southern Atlantic).	North Carolina yellow pine.	Shortleaved pine (Va., N. C., S. C.).
	North Carolina pine.	

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[a] Part of the material in this circular is based upon Bulletin 13, Division of Forestry, "Timber Pines of the Southern United States," by Charles Mohr and Filibert Roth; and Circular 115, Forest Service, "Second Progress Report on the Strength of Structural Timber," by W. K. Hatt. Bulletin 13 can be obtained only from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a cost of 35 cents; Circular 115 may be obtained free from the Forest Service, United States Department of Agriculture.

Longleaf pine.

Pitch pine (Atlantic).
Longleaved yellow pine (Atlantic).
Longleaved pine (Atlantic).
Longleaved pitch pine (Atlantic).
Longstraw pine (Atlantic).
North Carolina pitch pine.
Georgia yellow pine.
Georgia pine.
Georgia heart pine
Georgia longleaved pine.
Georgia pitch pine.
Florida yellow pine.
Florida pine.
Florida longleaved pine.
Texas yellow pine.
Texas longleaved pine.

Shortleaf pine.

Carolina pine.
Slash pine (N. C., Va.).
Oldfield pine (Ala., Miss.).
Spruce pine.
Rosemary pine (N. C.).

Loblolly pine.

Bull pine (Texas, Gulf region).
Virginia pine.
North Carolina pine.
Sap pine (Va., N. C.).
Meadow pine (Fla.).
Black pine (Va.).
Foxtail pine (Va., Md.).
Indian pine (Va., N. C.).
Spruce pine (Va.).
Bastard pine (Va., N. C.).
Yellow pine (No. Ala., N. C.)
Swamp pine (Va., N. C.).
Longstraw pine (Va., N. C., Ark.).

BOTANICAL DESCRIPTION.

Commercially, the southern pines are often roughly divided into three classes: (1) "Longleaf"—heavy and close-grained timber of the best grade regardless of its true botanical classification; (2) "shortleaf"—timber of an intermediate grade; (3) "loblolly"—rapid growth more or less knotty material not valuable enough to be classed as "shortleaf." Most of the timber classed as "longleaf" is true longleaf, although occasionally clear heavy sticks of shortleaf and loblolly are marketed as "longleaf." Cuban pine has a comparatively small cut compared with longleaf, shortleaf, and loblolly, and is usually classed as "longleaf." This system of classification has tended to throw loblolly pine into disrepute as a structural timber, while in reality much of the material classed as shortleaf is loblolly and vice versa. Sometimes the southern pines are commercially divided into but two classes—longleaf and shortleaf, descriptive entirely of quality. The botanical characteristics which will enable the three principal southern pines to be distinguished in the field are given in Table 2.

TABLE 2.—*Botanical characteristics of the three principal pines of the Southern States.*

	Longleaf pine.	Shortleaf pine.	Loblolly pine.
Leaves	Three in a bundle, 9 to 12 (exceptionally 14 to 15) inches long.	Two and three in a bundle, $1\frac{3}{8}$ to 4 inches long, commonly $2\frac{1}{2}$ to 4 inches.	Three in a bundle, 5 to 8 inches long.
Cones (open).	6 to 9 inches long, $4\frac{1}{2}$ to 5 inches in diameter.	$1\frac{1}{4}$ to 2 inches long; $1\frac{1}{8}$ to $1\frac{3}{4}$ inches in diameter.	$2\frac{1}{2}$ to $4\frac{1}{2}$ inches long; $1\frac{3}{4}$ to 3 inches in diameter.
Scales	$\frac{7}{8}$ to 1 inch broad; tips much wrinkled; light chestnut-brown; gray with age.	$\frac{5}{16}$ to $\frac{3}{8}$ (exceptionally $\frac{1}{2}$) inch broad; tips light yellow-brown.	$\frac{3}{8}$ to $\frac{3}{4}$ inch broad; tips smooth, dull yellow-brown.
Prickles	Very short, delicate, incurved.	Exceedingly short ($\frac{1}{10}$ inch); delicate; straight; declined.	Short; stout at base.
Buds	$\frac{3}{4}$ inch long, $\frac{1}{2}$ inch in diameter; silver white.	$\frac{3}{8}$ to $\frac{1}{2}$ inch long, about $\frac{1}{8}$ inch in diameter; brownish.	$\frac{1}{2}$ to $\frac{3}{4}$ inch long, $\frac{1}{4}$ inch in diameter; brownish.

DISTRIBUTION.

Longleaf, shortleaf, and loblolly pine trees do not, as a rule, exceed 30 inches in diameter and 100 feet in height. Logs cut from the southern pines average below 20 inches in diameter at the top.

Longleaf pine commonly grows in pure stands of wide extent to the almost complete exclusion of other species. It occurs principally in a belt 200 miles wide in the lower part of the Southern States which border upon the Atlantic Ocean and the Gulf of Mexico. As longleaf pine requires considerable direct sunlight for its proper development and grows slowly during its early life, it is likely, except in very sandy soil, to be suppressed by competing trees of more rapid growth; therefore the chances for its reproduction on cut-over areas when left to the ordinary course of nature are limited. Longleaf attains a diameter of 16 inches breast-high, with a height of about 100 feet, in from one hundred and ten to one hundred and forty years.

Shortleaf pine is a tree of the plains and foothills; in the South it rarely grows above an altitude of 2,500 feet, and in the northern portion of its range not above 1,000 feet. East of the Mississippi River the tree appears scattered among the hardwoods, while west of the Mississippi it forms large forests on the table-lands of the hill country, especially in Arkansas, northern Louisiana, and Missouri. Under favorable conditions shortleaf reaches a diameter of 16 inches breast-high and a height of about 85 feet at an average age of one hundred and ten years.

Loblolly pine has taken a most prominent part in the renewal of the forests of the southern Atlantic States on lands which were once cleared. It grows rapidly when young and does not demand so much direct sunlight as the other southern pines. East of the Mississippi loblolly pine frequents the low pine barrens and their swampy borders, and farther back from the coast is found on the table-lands of northern Mississippi, Alabama, Georgia, and South Carolina. West of the Mississippi there are heavily timbered areas of loblolly in Arkansas, Louisiana, and the eastern edge of Texas. Of the "yellow pine" from Arkansas, it may be assumed that about one-half is loblolly and one-half shortleaf. Loblolly pine reaches a diameter of 16 inches breast-high and a height of about 90 feet in from forty to ninety-five years. Trees twenty years old average about 45 feet in height and from 4 to 6 inches in diameter breast-high.

ENEMIES.

Like all trees, the southern pines are subject to injury by fires, live stock, storms, fungi, and insects. In addition, great injury is caused to longleaf pine forests by the destructive methods employed in turpentine operations. The trees should, of course, be handled so as to yield their turpentine products, but the prevailing methods are unnecessarily severe.

The large amount of sapwood in loblolly renders it liable to the attacks of fungi and insects. The mycelium of large polyporous fungi frequently infests the living tree, destroys the cell walls, causes the wood to assume a reddish color, and makes it very brittle. Shortleaf is affected by insects less than the other southern pines.

The staining or "bluing" of lumber in process of air seasoning is common and is due to a fungus. Bluing causes a considerable depreciation in the value of finishing lumber, but has apparently no effect upon the strength. Kiln-drying is commonly used to prevent it.

PHYSICAL PROPERTIES.

APPEARANCE AND CHARACTERISTICS OF WOOD.

The wood of all the southern pines is very much alike in appearance. The sapwood and heartwood are distinctly marked, the sapwood being yellowish-white and the heartwood reddish-brown. The transformation from sapwood to heartwood begins when the tree is about twenty-five years old, but does not keep pace with the annual growth, since it is more retarded as the tree grows older. Sapwood contains much less resinous matter and in it the resin is limpid and exudes from a fresh cut, while it seldom does so in the heartwood. The heartwood of old logs is generally heavier than the sapwood on account of being formed when the tree was comparatively young and vigorous. Of the three principal pines, longleaf has the least sapwood and loblolly the most, while shortleaf occupies an intermediate position. The layers of growth or annual rings show distinctly in the wood of these pines, and the width of the annual rings generally varies with the age period of the tree, being greatest when the tree is young and vigorous and least in the sapwood of mature trees. The two bands of dark summer wood and lighter colored spring wood in each year's growth are distinct in the southern pines. Longleaf averages about 20 rings to the inch in fully grown timber and is more uniform than in the case of shortleaf and loblolly. In loblolly 6 rings to the inch is an average, although the rate of growth varies greatly and rings over one-half inch wide are not uncommon. Shortleaf averages 12 rings to the inch, but also has a considerable range in rate of growth. The specific gravity of the spring wood is about 0.40, while that of the summer wood is about 0.95, so that the weight of the wood increases with the larger proportion of summer wood, which generally forms less than half of the total volume of the whole log. The proportion of summer wood varies somewhat according to age and is generally greatest in early middle life and least in extreme youth and old age. On an average the amount of summer wood is greater in longleaf than in shortleaf or loblolly. Summer wood forms a very useful criterion for judging the weight of timber. The wood of the southern pines is generally straight grained, but some trees have a spiral grain which causes "cross-grained" lumber. The elements composing the wood fiber of the southern pines are few and simple. The fibers or cells running lengthwise with the trunk form about 90 per cent of the wood by volume, and the pith rays placed at right angles to them and lying radially form about 8 per cent. The remaining 2 per cent is made up of the resin ducts, small passages scattered throughout the wood, but forming more or less connected systems.

It is comparatively easy to distinguish the different southern pines in the field, but difficult and often impossible to distinguish them by examining small pieces of their wood. Some characteristics of their woods are given in Table 3 by which general differences, when a pile of logs or a quantity of lumber is under inspection, may be noted.

TABLE 3.—*Physical characteristics of the wood of southern pines.*

	Longleaf pine.	Shortleaf pine.	Loblolly pine.
Specific gravity of kiln-dried wood:			
Possible range	0.50 to 0.90	0.40 to 0.80	0.40 to 0.80.
Most frequent range	0.55 to 0.65	0.43 to 0.53	0.45 to 0.55.
Weight, pounds per cubic foot, kiln-dried wood, average	37.5	30	31.
Character of grain seen in cross section.	Fine and even; annual rings quite uniformly narrow in structural lumber, with an average of generally 12 to 20 rings to the inch.	Very variable; medium coarse; rings wide near heart, followed by zone of narrow rings; not less than 4 (mostly 10 to 15) rings to the inch in structural lumber, but often very fine grained.	Variable, mostly very coarse; 3 to 12 rings to the inch in structural lumber, generally wider than in shortleaf.
General color	Even; dark reddish-yellow to reddish-brown.	Whitish to reddish-brown.	Yellowish to reddish and orange brown.
Sapwood	Little; rarely over 2 to 3 inches of radius in trees upward of 12 inches in diameter breast-high.	Commonly about 4 inches of radius in trees upward of 12 inches in diameter breast-high.	Very variable; 3 to 6 inches of the radius in trees upward of 12 inches in diameter breast-high.
Resin	Very abundant; parts often turning into "lightwood;" pitchy throughout.	Moderately abundant; least pitchy; only near stumps, knots, and limbs.	Abundant; more than shortleaf, less than longleaf and Cuban.

SHRINKAGE.[a]

The wood of the southern pines does not differ materially in its action under shrinkage. When a piece of green or wet wood is dried, no change in dimensions takes place until the fiber-saturation point[a] is passed. The wood then begins to shrink in cross-sectional area until no further moisture can be extracted from the cell walls, the contraction varying uniformly with the removal of moisture. The wood also shrinks longitudinally, but the amount of this shrinkage (one-tenth of 1 per cent) is so small as to be negligible. Generally, the heaviest wood shrinks the most, and sapwood shrinks about 25 per cent more than heartwood of the same specific gravity. The presence of resin in wood decreases the shrinkage. The shrinkage of wood from the upper part of the tree is usually from 15 to 20 per cent less than that from the butt pieces.

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[a] See Bulletin No. 10, Division of Forestry, "Timber: An Elementary Discussion of the Characteristics and Properties of Wood," by Filibert Roth. This can be obtained only from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a cost of 10 cents.

Shrinkage is due to the contraction of the cell walls, and is greater around the circumference of a log than in a radial direction. This difference is due partly to the pith rays which lie radially and tend to check any change in that direction, and partly to the difference in weight in the alternate bands of spring and summer wood. Because of this and because of the difference in the wood cells in shape, size, and thickness of walls, and in their arrangement, shrinkage is not uniform. This irregularity produces strains that cause warping and checking to a greater or less degree, depending upon the manner of seasoning.

The wood of the southern pines shrinks about 10 per cent in cross section or volume (neglecting longitudinal shrinkage) when dried from a green to an oven-dry state. From 3 to 4 per cent of this shrinkage occurs along the radius, and from 6 to 7 per cent around the circumference. In the usual air-dry condition, from 12 to 15 per cent of moisture still remains in the wood, so that the shrinkage from the green to the air-dry condition is only a trifle over half of that from the green to the absolutely dry state. Wood that has shrunk will return to its original size if soaked.

KILN-DRYING.[b]

Practically all of the lumber manufactured from the southern pines is kiln-dried before leaving the sawmill yard. This drying prevents "bluing," lessens the shipping weight, and reduces the tendency to further shrinkage.

The kilns used generally belong to one of two classes: The radiator class, in which the lumber is heated by coils of steam pipes under the floor; and the blower class, in which the heat is supplied by a current of air, heated in a chamber outside of the kiln proper and forced in by a fan. Radiator kilns probably have the wider use. In both systems, if properly designed, there is provision for the regulation of the temperature, the volume, and the humidity of the air used for drying.

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[a] See p. 24. For a full discussion of the fiber-saturation point, see Forest Service Circular 108, "The Strength of Wood as Influenced by Moisture," by H. D. Tiemann.

[b] See Forest Service Circular 48, "Kiln-Drying Hardwood Lumber," by Frederick Dunlap.

What is known as the progressive system is commonly used. This requires a drying chamber at least 50 feet long. The lumber is carried through the chamber on trucks holding several thousand feet. The boards are carefully piled with spacing pieces between the layers, so as to allow free circulation of air. The trucks are run in at one end of the chamber and removed from the other after they have occupied successive positions throughout its length. Temperature and moisture are so regulated that the lumber is first moistened, then heated, and finally dried out, all stages of the process going on progressively in the kiln at the same time.

For successful kiln-drying, both the wood and the water it contains should be raised to the temperature at which the drying is to take place. If the wood is slowly heated and the surface moisture carried away, the surface will become entirely dry before the interior is heated and the lumber will shrink and check on the surface. Surface drying should be delayed in the kiln by retaining the moisture first vaporized while the heat penetrates to the interior. Steam may be used to wet the wood and raise it to the drying temperature. When the inside as well as the surface of the wood are at the proper temperature, drying may proceed, care being taken to replace the heat lost from the wood by vaporization by the heat of the kiln.

MECHANICAL PROPERTIES.

STRUCTURAL MATERIAL.

Material for structural purposes is chosen for its strength, stiffness, and durability. Longleaf pine possesses these properties to such a high degree that it has long been the standard structural timber in the eastern United States, and has only lately found rivals among the Pacific coast timbers in the lumber markets of the Middle States. Shortleaf and loblolly, while not so strong or durable as longleaf, have found an increased use as structural timbers because of the decreasing supply of longleaf and through the introduction of preservative processes which increase their durability.

METHOD OF TESTING.[a]

The bending tests on structural timber recorded in this circular were made on full-sized pieces, such as are found on the market. The pieces were chosen to represent the average class of timber that contains defects such as are common in commercial material.

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[a] For detailed description of methods used in the tests see Forest Service Circular 38 (revised), "Instructions to Engineers of Timber Tests."

In a bending test the beam is supported at the ends and loaded at the middle or at two points one on each side of the middle. This second method of loading corresponds more nearly to the condition of uniform loading generally met in practice. Figure 1 shows a bridge stringer under test. The supports for the beam are on the weighing platform of the testing machine, so that the load on the beam can be determined at any time during the test. This load is applied by a crosshead which can be forced down on the test specimen by means of heavy screws turned by a train of gears. When the load is applied at two points an auxiliary straining beam is attached to the crosshead. The deflection or bending of the beam is measured by a fine wire stretched along the axis between two nails driven into the beam near the ends and a scale attached to the side of the beam at the center. When the beam bends, the scale moves down while the wire maintains its original position, so that the change in the position of the wire on the scale shows the deflection.

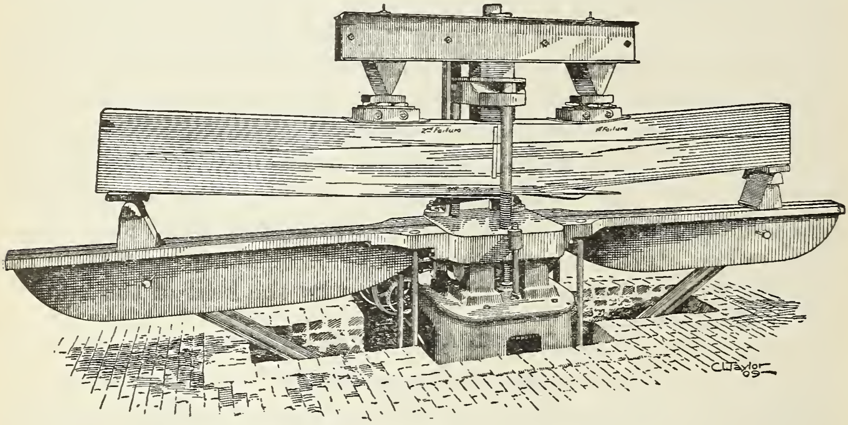


FIG. 1.—Method of testing a bridge stringer in bending.

The test is conducted by loading the beam with about one-twentieth of the probable breaking load and noting the deflection. The load is then increased by a certain increment which is recorded with the corresponding deflection, and the process continued until the beam breaks. In computing the results the breaking strength is represented by "modulus of rupture," the stiffness by "modulus of elasticity" and the load the material will carry without taking a set after this load is removed by "fiber stress at the elastic limit." The results of tests on beams of various sizes are thus reduced to a unit basis so that direct comparisons as to strength and stiffness can be made between pieces of different sizes of the same or different species of wood. In a beam under test, there is a tendency for the upper and lower halves to split apart at the ends. Sticks breaking in this way are said to fail in longitudinal shear.

Since the amount of water in lumber has considerable influence on its physical and mechanical properties, the moisture condition of tested pieces is determined by cutting an inch section from them and drying the section at 100° C. until it no longer loses weight. The loss in weight, divided by the dry weight, is taken as the moisture per cent of the piece at the time of test.

STRENGTH AND STIFFNESS OF LARGE BEAMS.

The strength and stiffness of longleaf, shortleaf, and loblolly pine in the form of structural timbers, such as are found on the market, are shown in Table 4. This table also gives the average unit fiber stresses at which failure occurred, and the weight per cubic foot at several conditions of seasoning.

TABLE 4.—*Strength and stiffness of merchantable grade 8 by 16 inch beams tested in bending over a span of 15 feet.*

Species.	Locality of growth.	Condition of seasoning at time of test.	Weight per cubic foot.		
			Green, 40 per cent moisture.	Air dry, 20 per cent moisture.	Oven dry, 0 per cent moisture.
			Pounds.	*Pounds.*	*Pounds.*
Longleaf pine	South Carolina	Partially air dry, 25 per cent moisture	50.7	43.5	36.2
Shortleaf pine	Arkansas	Green, 37.8 per cent moisture	40.5	34.8	28.9
Loblolly pine	South Carolina	Green, 50.9 per cent moisture	46.4	39.7	33.1

Species.	Breaking load and deflection under 15,000 pounds load.						Average unit fiber stress.
	Average.		Maximum.		Minimum.		
	Pounds.	*Inches.*	*Pounds.*	*Inches.*	*Pounds.*	*Inches.*	*Pounds per square inch.*
Longleaf pine	81,500	0.36	114,000	0.48	62,000	0.28	7,160
Shortleaf pine	59,600	.42	66,600	.49	49,500	.38	5,230
Loblolly pine	64,200	.39	70,800	.49	50,500	.32	5,620

GRADING.

The amount of sapwood present is the chief factor in determining the grade of southern pine structural material. Before the introduction of preservative processes and when first-class heart material was more plentiful than at present, grading rules were very strict as to the exclusion of sapwood. However, the rules of most associations have recently been revised to allow a larger proportion of sapwood in the higher grades. The rate of growth, the size, number, and condition of knots and the amount of wane are also considered in grading rules. Ring shakes on the ends and deep checks along the sides are allowed only in the low grades. The present tendency of grading rules is to require less perfection in each grade, but to be more specific in limiting the grades.

TABLE 5.—*Bending strength of large sticks.*

LONGLEAF PINE.

Reference number.	Locality of growth.	Dimensions.		Grade.	Condition of seasoning.		Number of tests.	Moisture per cent.	Rings per inch.	Specific gravity, dry.	Weight per cu. ft.		Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Elastic resilience.	Number failing by longit. shear.	Remarks.
		Section.	Span.								As tested.	Oven dry.						
											Lbs.	*Lbs.*	*Lbs. per sq. in*	*Lbs. per sq. in.*	*1,000 lbs. per sq. in.*	*Inch lbs. per cu. in.*		
1	South Carolina..	6″x 8″ 10″x16″	15′ 0″...	Merchantable .	Partially air dry.	Average....	22	25.0	13.7	0.58	45.6	36.2	3,800	7,160	1,560	0.53	9	
						Maximum .	....	40.3	25.4	.76	60.0	47.5	4,970	10,020	2,010	.78		
						Minimum..	....	17.3	6.2	.50	39.4	31.2	2,220	5,450	1,190	.21		
2	Georgia.........	10″x12″	15′ 0″...	Merchantable .	Partially air dry.	Average....	22	27.3	18.0	.69	54.7	42.9	5,581	8,384	1,820	......	6	Excellent merchantable grade.
						Maximum .	....	34.5	29.0	.79	.....	49.4	9,600	11,410	2,920	......		
						Minimum..	....	20.0	11.0	.50	.....	31.4	3,547	4,836	1,167	......		

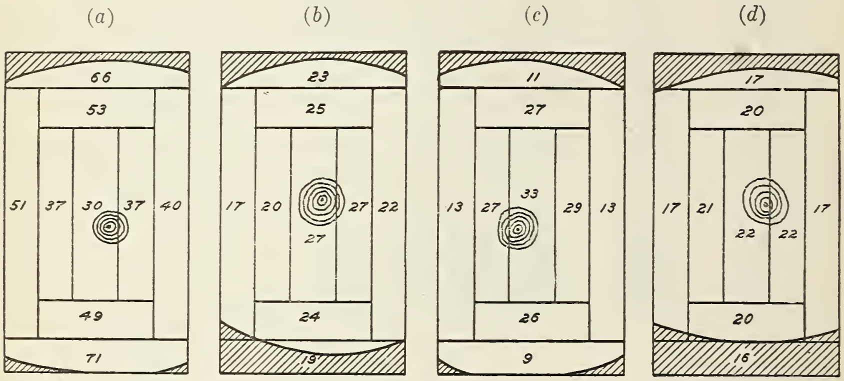
SHORTLEAF PINE.

Reference number.	Locality of growth.	Section.	Span.	Grade.	Condition of seasoning.		Number of tests.	Moisture per cent.	Rings per inch.	Specific gravity, dry.	As tested.	Oven dry.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Elastic resilience.	Number failing by longit. shear.	Remarks.
3	Arkansas........	5″x 8″ 8″x12″ 8″x14″ 8″x16″	15′ 0″...	Select.........	Green.........	Average....	25	50.4	11.7	0.51	48.2	32.0	3,420	6,060	1,630	......	8	
						Maximum .	....	98.1	22.0	.59	.....	.....	4,530	7,730	2,069	......		
						Minimum..	....	29.3	6.0	.42	.....	.....	2,590	4,200	1,117	......		
4	Arkansas........	5″x 8″ 8″x12″ 8″x14″ 8″x16″	15′ 0″...	Merchantable .	Green.........	Average....	47	46.0	12.2	.47	42.9	29.2	3,270	5,360	1,385	......	3	
						Maximum .	....	102.5	23.0	.53	.....	.....	4,510	6,920	1,926	......		
						Minimum..	....	30.0	7.0	.....	.....	.....	2,260	3,390	999	......		

LOBLOLLY PINE.

5	South Carolina..	6″x 7″ 6″x10″ 4″x12″ 6″x16″ 8″x14″ 8″x16″	10′ 0″ to 15′ 6″.	Square edge...	Green..........	Average....	42	48.0	5.7	0.50	46.2	31.2	3,150	5,580	1,426	0.45	7	
						Maximum .	....	92.1	11.7	.60	56.8	37.5	5,210	8,460	1,920	.99		
						Minimum..	....	30.2	2.3	.40	35.6	25.0	1,675	3,120	905	.07		
6	South Carolina..	6″x 7″ 4″x12″ 6″x10″ 6″x16″ 8″x16″ 10″x16″	10′ 0″ to 16′ 0″.	Square edge...	Partially air dry.	Average....	37	24.2	5.3	.50	38.7	31.2	3,180	5,670	1,380	.42	2	
						Maximum .	....	29.2	17.2	.58	45.6	36.2	4,850	8,100	2,040	.76		
						Minimum..	....	15.0	2.5	.41	31.2	25.6	1,730	2,910	906	.10		
7	Virginia.........	8″x 8″	6′ 0″ to 15′ 6″.	Square edge...	Green..........	Average....	17	64.0	3.0	.43	43.7	26.9	1,935	3,490	744	.31	0	Very rapid growth; poor quality.
						Maximum .	....	100.5	4.0	.51	51.9	31.9	3,185	4,720	1,193	.78		
						Minimum..	....	33.8	2.5	.35	35.0	21.9	956	2,180	357	.12		
8	Virginia.........	8″x 8″	6′ 0″ to 16′ 0″.	Square edge...	Partially air dry.	Average....	12	22.4	4.8	.46	35.6	28.8	3,260	5,180	1,180	.51	0	Rapid growth.
						Maximum .	....	27.7	8.8	.58	43.1	36.2	5,300	8,950	1,728	1.05		
						Minimum..	....	17.8	2.5	.37	30.0	23.1	1,280	2,180	606	.13		

Table 5 shows the bending strength of longleaf, shortleaf, and loblolly of several grades in green and partially air-dry states. Longleaf has the greatest strength and stiffness of the three species, as shown by the modulus of rupture and modulus of elasticity. The loblolly pine from South Carolina was graded as "square edge" because it showed considerable sapwood. The rules have been revised since the timber was graded, so that a part of the sticks at least would now be classed as "merchantable." A comparison of shortleaf and loblolly shows that loblolly of a square-edge grade ranks between the select and merchantable grades of shortleaf in strength and stiffness. The select shortleaf ranks higher than any of the loblolly. The strength and stiffness of loblolly and shortleaf may for all practical purposes be taken as the same. The small sticks of loblolly from Virginia were of rapid growth, knotty material of an inferior grade.



(a) Average 48 per cent green. Tested 3 days after leaving saw.

(b) Average 23 per cent air dry. Seasoned 3½ months in the open.

(c) Average 21 per cent kiln dry. In the kiln 6 days.

(d) Average 19 per cent air dry. Under cover 21 months.

FIG. 2.—Distribution of moisture in cross section midway of the length of 8 by 16 inch North Carolina pine beams: (*a*) Average of 10 sections; (*b*) average of 4 sections; (*c*) average of 4 sections; (*d*) average of 12 sections.

EFFECT OF SEASONING.

As shown by the results of the tests on small pieces, drying out below a certain point increases the strength of the wood fiber. In seasoning large timbers, the drying very often does not take place uniformly, and the outer layers lose their moisture much more rapidly than the interior of the stick. This uneven drying is very liable to cause checks and shakes that offset the increase in the strength of the wood fiber, and make the seasoned stick as a whole no stronger and sometimes even weaker than when green.

Figure 2 shows the distribution of moisture throughout the cross section of 8 by 16 inch loblolly pine stringers seasoned under various conditions. The logs from which the stringers were cut were floated to the mill, which accounts for the large amount of water in the outer portion of the green section. In the case of the material air-dried for three and a half months in the open, the surface moisture is greatly reduced, the center being only slightly affected. This class of material was checked to a considerable extent. The moisture in the kiln-dry timber was greatly reduced in the outer portions, but unchanged in the interior. The kiln-dry timber was very badly checked. The stringers dried under shelter had the most even distribution of moisture and were little injured by checking.

Table 6 gives the results of tests on material in the conditions of seasoning shown in figure 2. In the lower part of the table, the values are expressed in per cent of values for the green beams. The timber seasoned in the open has about the same strength as that in a green condition. In the case of the kiln-dry stringers, the strength was lowered by excessive checking. The material seasoned under shelter showed an increase in strength over the green timber of 20 per cent. In all cases the stiffness and the elastic limit were raised by seasoning. A large percentage of failures in longitudinal shear is noticeable among the seasoned timbers.

TABLE No. 6.—*Bending tests on loblolly pine beams under different conditions of seasoning.*

[8 by 16 inch section, 13½ to 15 foot span.]

	Number of tests.	Rings per inch.	Moisture per cent.	Weight per cubic foot oven dry, pounds.	Fiber stress at elastic limit, pounds per square inch.	Modulus of rupture, pounds per square inch.	Modulus of elasticity, 1,000 pounds per square inch.	Longitudinal shear at maximum load, pounds per square inch.	Condition of seasoning.
Average....	12	6.2	50.9	33.5	3,240	5,620	1,450	375_4	Green.
Maximum .		11.7	79.0	37.8	4,080	6,620	1,785	442	
Minimum..		3.3	36.0	29.9	2,285	4,440	1,145	296	
Average....	4	9.4	23.2	33.7	3,580	5,480	1,780	364_4	Air dry 3½ months in the open.
Maximum .		11.5	24.3	34.5	4,070	6,600	1,987	440	
Minimum..		8.0	21.5	32.5	3,090	5,000	1,530	327	
Average....	5	7.7	20	33.9	4,512	5,060	1,685	333_3	Kiln dry 6 days.
Maximum .		10.2	22	38.0	5,840	7,320	1,790	488	
Minimum..		4.7	18	27.7	3,180	2,150	1,410	143	
Average....	12	7.7	19.7	34.6	4,331	6,721	1,688	493_9	Air dry 21 months under shelter.
Maximum .		9.5	21.7	40.4	4,990	8,560	2,002	620	
Minimum..		5.5	18.2	28.6	3,110	5,160	1,398	380	
		Relative values. Green=100.							
		100	100	100	100	100	100	100	Green.
		152	46	101	110	98	123	97	Air dry 3½ months in the open.
		124	39	101	139	90	116	89	Kiln dry 6 days.
		124	39	103	134	120	116	131	Air dry 21 months under shelter.

NOTE.—Figures written as subscripts to the figures for longitudinal shear indicate the number of sticks failing in that manner.

An analysis of the tests on green 8 by 16 inch bridge stringers of loblolly pine was made to determine the effect of various amounts of sapwood on the strength. It appears from this analysis that in large beams the per cent of sound sapwood does not influence the strength or stiffness.

Southern pine structural timber is very often sawed box heart, and often the pith falls near the center of the beam. Season checks in such timber run from the surface toward the center, are usually on the sides of the beam opposite the pith, and tend to cause failure by longitudinal shear.

The results given in Table 6 indicate that if the timber is carefully seasoned under shelter, so as to make the drying as uniform as possible, the strength may be increased, but that for the general run of structural material, subjected to all sorts of seasoning conditions, it is hardly safe to count on more than the green strength.

EFFECT OF KNOTS.

Knots are classified with respect to their size and condition. Pin knots are not over one-half inch in diameter. Small knots are from one-half inch to 1½ inches in diameter. Large knots are all over 1½ inches in diameter. In describing condition, such terms as sound, rotten, loose, and encased (surrounded entirely or in part by bark or pitch) are used. Pith knots are sound knots with pith holes not over one-half inch in diameter. The strength of a beam is influenced by the presence of a knot, depending upon the position, size, and condition of the knot. A sound, tight knot is less harmful than a loose or rotten one. A comparatively small knot situated near enough to the lower edge of a beam to turn the grain off is more harmful than a larger knot so placed as to allow the grain to be continuous in passing. The nearer a knot is to the neutral[a] plane the less it weakens the stick. In some cases, knots near the neutral plane may act as pins, and tend to strengthen a beam against failure in longitudinal shear. Knots in the top of a stick are not so weakening as those in the bottom. As a general rule, loblolly pine beams with knots in the middle half of the length, one-fourth of the height from the top or bottom, have about 75 per cent of the strength of sticks with knots in the remaining portions.

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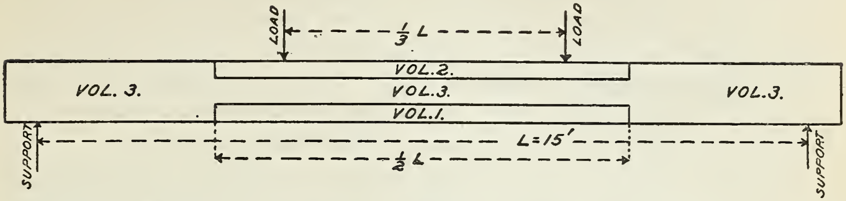
[a] Plane between upper and lower halves when beam is horizontal.

TABLE 7.—*Effect of knots—loblolly pine beams loaded at two points.*



	Group I.		Group II.		Group III.		Relative value of groups.					
	Large beams.	Small beams.	Large beams.	Small beams.	Large beams.	Small beams.	Large beams.			Small clear beams.		
							I.	II.	III.	I.	II.	III.
Number of tests	33	19	15	12	11	20	......	......	......	......	......	......
Per cent of sap:												
Average	42	......	52	......	45	......	115.5	93.3	100	......	......	......
Maximum	92	......	85	......	93	......						
Minimum	8	......	0	......	12	......						
Rings per inch:												
Average	5.6	6.0	6.2	8.2	6.5	9.6	86.2	95.5	100	62.5	85.5	100
Maximum	8.2	10.0	10.0	12.0	9.2	28.0						
Minimum	3.2	3.0	4.0	5.5	5.5	3.0						
Moisture per cent:												
Average	65	23.6	75	28.0	57	23.6	114.0	131.7	100	100	118.6	100
Maximum	101	34.7	101	51.1	62	26.5						
Minimum	40	19.6	38	21.6	47	20.4						
Specific gravity (dry):												
Average	0.495	0.452	0.481	0.482	0.460	0.510	107.7	104.4	100	88.7	94.6	100
Maximum	.578	.536	.510	.527	.470	.692						
Minimum	.438	.397	.440	.448	.440	.438						
Fiber stress at elastic limit, pounds per square inch:												
Average	2,830	4,766	3,000	4,730	3,820	5,170	74.1	78.6	100	92.3	91.5	100
Maximum	3,820	6,080	3,810	5,770	4,540	6,500						
Minimum	2,050	2,860	2,010	3,770	3,310	4,220						
Modulus of rupture, pounds per square inch:												
Average	4,580	7,798	5,030	8,230	6,390	9,260	71.7	78.6	100	84.2	88.8	100
Maximum	6,130	9,030	6,510	9,110	7,260	12,470						
Minimum	2,300	5,790	3,640	6,930	5,420	7,070						
Modulus of elasticity, 1,000 pounds per square inch:												
Average	1,365	1,360	1,375	1,585	1,675	1,550	81.5	82.1	100	87.7	102.5	100
Maximum	1,875	1,652	1,623	2,154	2,040	1,880						
Minimum	912	797	1,070	1,076	1,260	1,075						
Longitudinal shear at maximum load, pounds per square inch:												
Average	228	259	252	273	318	306	71.7	79.2	100	84.6	89.3	100
Maximum	307	298	325	301	363	412						
Minimum	114	192	182	229	271	235						
Number failing due to defects in volume	23	......	12	......	0	......	......	......	......	......	......	......

To make a study of the influence of knots on the strength of structural timbers, loblolly pine beams 5 inches by 12 inches in cross section, representing the range in market material, were tested in bending over a 15-foot span. Table 7 gives the analysis of the large beams tested, and shows also the results secured from tests on small beams free from defects cut after test from the uninjured portions of the large beams.

The timbers were divided into three groups, the grouping being based on the position of knots and cross grains. The sketch at the top of the table shows the method of dividing the beams into three volumes: Volume 1 includes the middle half of the beam one-quarter of the height up from the bottom side. Volume 2 includes the middle half of the beam one-quarter of the height down from the top side. Volume 3 consists of the remainder of the beam.

All beams having knots or cross grains in volume 1 were placed in group 1. All beams having knots or cross grains in volume 2, but having volume 1 free from defects, were placed in group 2, and all beams having defects in volume 3, but having both volumes 1 and 2 free from defects, were placed in group 3.

It will be seen by comparing the figures in the items "Number of tests" and "Number failing due to defects in volume," that of the 33 beams in group 1, 23 failed due to a defect in volume 1; of the 15 beams in group 2, 12 failed on account of a defect in volume 2; of the 11 beams in group 3 in no case was failure due to a defect. It seems, therefore, that knots and cross grains near the bottom or tension face will in nearly all cases cause failure; when the tension face is free from defects and knots occur on the top or compression face, as is the case in beams in group 2, the beams will fail in compression; when both tension and compression faces are clear, defects in other parts of the beam seldom cause failure.

In the right-hand part of the table, the averages of different values tabulated are expressed in per cent of similar values secured from tests on beams in group 3. It will be seen that knots on the tension face reduce both the fiber stress at elastic limit and the modulus of rupture. The modulus of elasticity seems to be less influenced by defects. It will also be seen from the table that defects occurring in volume 2 do not reduce the strength functions as much as when they occur in volume 1. These results show that the position of a knot in a beam is a much more important factor than the size of the knot, and that, whenever possible, knots on the tension face should be avoided.

The difference in strength of the three groups is not, however, entirely due to the position and number of defects; it is almost invariably the case in loblolly pine that timbers containing a large number of knots are lighter and contain wood of poorer quality than timbers free from knots. Knots are characteristic of material secured from upper cuts, while clear material is more often secured from butt cuts. The tests made on small clear beams, cut from the large specimens after test, show that there was a difference in the quality of even the clear wood in the different groups.

TABLE .—*Showing relation between rate of growth and bending strength for longleaf, shortleaf, and loblolly pine in structural sizes.*

Rings.	Rings per inch.	Per cent of sap in cross section.	Modulus of rupture, pounds per square inch.	Modulus of elasticity, 1,000 pounds per square inch.	Number tested.
LONGLEAF.					
Average of all	13.5	6.0	6,493	1,433	12
Average 10 per cent, highest	23.6	7.5	6,855	1,250	2
Average 10 per cent, lowest	6.6	12.5	6,270	1,304	2
Maximum single	25.4	13.0	7,250	1,310	1
Minimum single	6.2	6.0	6,040	1,242	1
LOBLOLLY.					
Average of all	5.2	45.3	5,191	1,289	81
Average 10 per cent, highest	10.3	16.5	6,065	1,670	8
Average 10 per cent, lowest	2.7	63.0	3,427	689	8
Maximum single	17.2	8.0	6,770	1,262	1
Minimum single	2.5	83.0	2,995	357	1
SHORTLEAF.					
Average of all	11.9	26.8	5,609	1,477	72
Average 10 per cent, highest	19.7	24.0	5,805	1,477	7
Average 10 per cent, lowest	7.1	33.7	5,294	1,436	7
Maximum single	23.0	40.0	5,040	1,272	1
Minimum single	6.0	44.0	5,680	1,498	1

EFFECT OF RATE OF GROWTH.

The rate of growth in structural material generally varies considerably throughout the cross section of any one stick. On this account, it is rather difficult to associate the number of rings per inch with strength. In Table 8, the results of a series of tests on structural timber have been arranged to show the effect of rate of growth. The table indicates in a general way, that in southern pine timber the strength decreases with decrease in number of rings per inch, or in other words that close-grained timber is generally the stronger.

SMALL PIECES.

KINDS OF TESTS.

Clear, straight-grained specimens are needed in investigating the effect of various physical characteristics on the strength of wood, and also in determining the strength of the wood itself free from the influence of defects.

Pieces 2 by 2 inches in section have been found well suited to tests of this kind. For bending, they are cut about 30 inches long, and for compression parallel to the grain and compression perpendicular to grain from 6 to 10 inches long. The blocks for shear parallel to grain are cut with a projecting lip that is sheared off under test. In making bending tests on small pieces, the loads and their corresponding deflections are recorded as in the case of large beams. Tests in compression parallel to grain are made by crushing the specimens endwise as they stand upright on the platform of the testing machine. In the case of compression perpendicular to grain, the tests are made by placing a piece of metal from 2 to 4 inches wide across the test specimen as it lies flat on the platform of the machine and pressing the piece of metal against the block of wood by means of the crosshead of the machine. This test is carried only slightly beyond the elastic limit of the wood under test, as loading beyond this point has at present no significance. The action is similar to that of a rail on a tie. In making the shearing tests on small pieces, the blocks are clamped firmly in a frame with the lip projecting. The frame is placed on the platform of the machine, and the lip sheared off by means of a sliding plate mounted in the frame. The plate is forced against the lip by the crosshead.

Table 9 gives a summary of the results of four different kinds of tests on small pieces of longleaf, shortleaf, and loblolly. Longleaf shows the greatest strength in bending, crushing, compression at right angles to grain, and shearing. Shortleaf and loblolly average about the same.

TABLE 9.—*Summary showing the strength of longleaf, shortleaf, and loblolly pine for small, clear, green specimens.*

	Average dry weight.	Average rings per inch.	Bending—modulus of rupture.	Compression.		Shear.
				Parallel to grain—crushing strength.	Perpendicular to grain—strength at elastic limit.	Shearing strength parallel to grain.
	Pounds per cubic foot.		*Pounds per square inch.*	*Pounds per square inch.*	*Pounds per square inch.*	*Pounds per square inch.*
Longleaf pine	36.5	18.0	9,070	[a] [b] 4,800	[b] 572	[b] 973
Shortleaf pine	30.0	13.4	7,724	3,577	400	707
Loblolly pine	30.0	5.3	7,870	4,100	469	630

[a] Size of specimens, 4 by 5 by 16 inches.

[b] Partially air dried.

RELATIVE STRENGTH OF LARGE AND SMALL PIECES.

The comparative bending strength of large sticks and small sticks cut from them is shown in Table 10.

It may be seen from this table that the bending strength of the large sticks of longleaf, shortleaf, and loblolly is about 75 per cent of the strength of the small sticks cut from them. The stiffness as shown by the modulus of elasticity is about the same in the large and small sticks.

TABLE 10.—*Comparative bending strength of large and small sticks.*

Reference No.	Locality of growth.	Dimensions.		Number of tests.	Rings per inch.	Moisture per cent.	Average.			Maximum.			Minimum.		
		Section.	Span.				Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.
	LONGLEAF PINE (PARTIALLY AIR DRY).														
							Lbs. per sq. in.	*Lbs. per sq. in.*	*1,000 lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*1,000 lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*1,000 lbs. per sq. in.*
1.....	South Carolina....	6″x8″ and 10″ x 16″.	180″..............	22	13.7	25.0	3,800	7,160	1,560	4,970	10,020	2,010	2,220	5,450	1,190
		2″x2″...........	30″..............	15	14.1	33.9	4,950	9,070	1,540	6,190	10,820	2,110	2,250	7,910	1,107
	Ratio of large sticks to small.	....	....	......	......	......	.77	.79	1.01	.80	.93	.95	.99	.69	1.08
	SHORTLEAF PINE (GREEN).														
2.....	Arkansas.........	5″x8″ to 8″x16″.	180″..............	72	12.0	47.6	3,330	5,600	1,472	4,530	7,730	2,069	2,260	3,390	999
		2″x2″...........	30″..............	254	13.6	51.7	4,350	7,710	1,395	7,400	11,000	2,093	2,250	4,020	703
	Ratio of large sticks to small.	....	....	......	......	......	.77	.73	1.06	.61	.70	.99	1.00	.85	1.42
	LOBLOLLY PINE (GREEN).														
3.....	South Carolina....	6″x7″ to 8″x16″.	120″ to 186″.....	42	5.7	48.0	3,150	5,580	1,426	5,210	8,460	1,920	1,675	3,120	905
		2″x2″...........	30″..............	44	5.4	70.9	4,100	7,870	1,440	6,190	10,670	2,260	2,250	4,110	712
	Ratio of large sticks to small.	....	....	......	......	......	.77	.71	.99	.84	.79	.85	.75	.76	1.27

EFFECT OF MOISTURE.

Moisture exists in wood in two conditions—that which is contained in the cell walls and that which fills the various open spaces in the cells. The latter, or "free" water[a] as it is often called, has no effect on the strength. If a piece of green wood is dried it first loses the free water, and until this is gone and the water in the cell walls begins to grow less the strength remains the same. The relation of bending strength to moisture for loblolly pine is shown in figure 3.

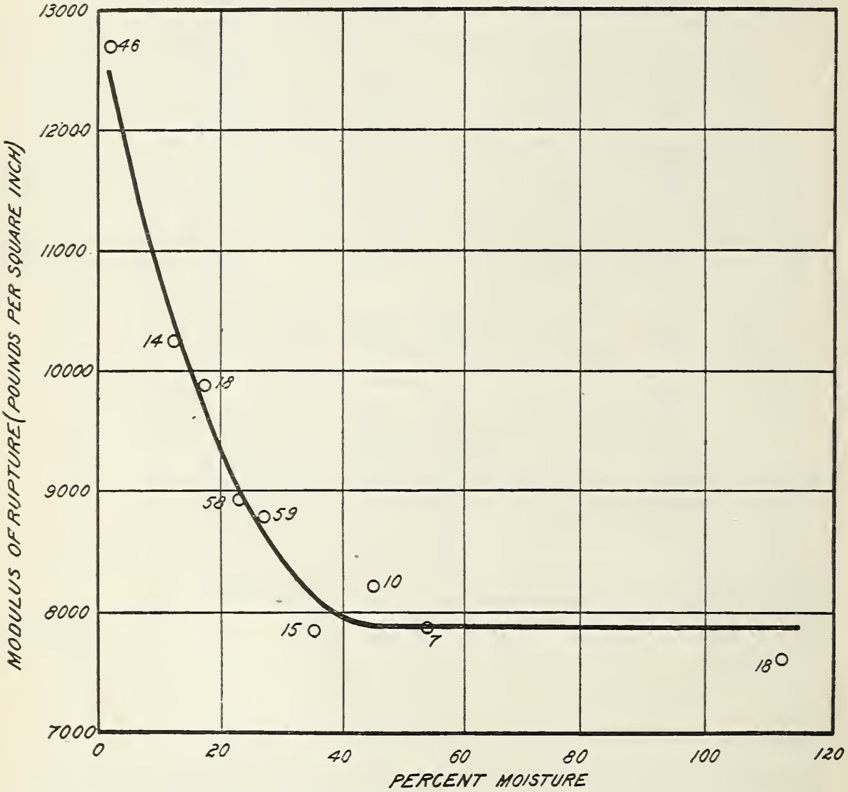


FIG. 3.—Relation between moisture and bending strength for loblolly pine. Size of specimens, 2 by 2 by 30 inches. Figures at O, number of tests averaged.

It may be seen that above about 35 per cent moisture there is no change in strength, while if the moisture is reduced below 35 per cent the strength increases rapidly.

When the cell walls reach their maximum absorption the wood is said to be at the fiber-saturation point. It should be noted in the case of specimens dried so as to cause an uneven distribution of moisture throughout the cross section that the resulting moisture-strength curve will be above the curve for evenly dried specimens, and will be gradually rounded off from the wettest to the driest condition. This condition of uneven dryness will generally be true of structural material. The specimens used in figure 3 were slightly case-hardened, due to the surface being a little more seasoned than the interior, and on this account the diagram is slightly rounded instead of making a sharper angle at the fiber-saturation point. The strength of clear pieces of wood when dried from a green to an oven-dry condition increases about three times. The fiber-saturation point of various species appears to vary between 20 and 40 per cent moisture. Moisture-strength diagrams for longleaf and shortleaf have the same general form as that for loblolly.

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[a] See Forest Service Circular 108.

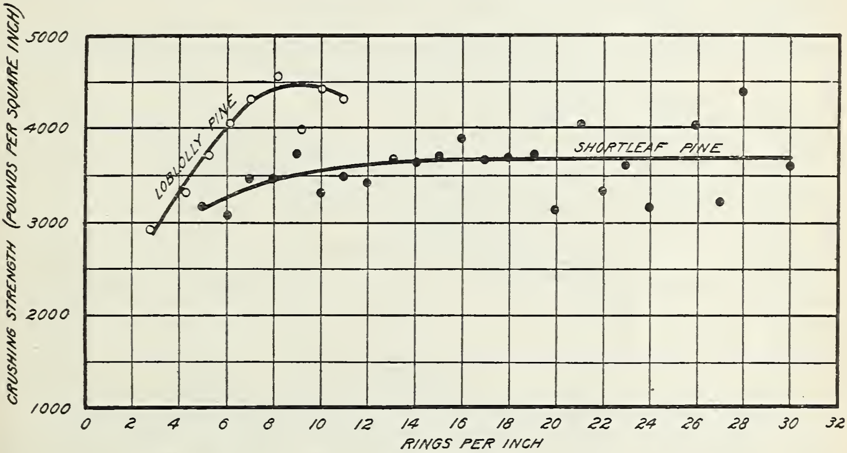

FIG. 4.—Relation between rate of growth and crushing strength for loblolly and shortleaf pine. Shortleaf: Number of tests, 284; size of specimens, 2 by 2 by 8 inches. Loblolly: Number of tests, 162; size of specimens, 2 by 2 by 4 inches.

In investigating the effect of rate of growth, weight, etc., on the strength of wood, green specimens are used in order to eliminate the influence of moisture.

EFFECT OF RATE OF GROWTH.

Diagram 4 shows the relation between rate of growth and strength for loblolly and shortleaf pine. In the case of loblolly the strength increases rapidly with the rings per inch, reaching a maximum between eight and ten rings and then falling off slightly. Shortleaf pine shows little change in strength with varying rates of growth. The strength increases slightly until a rate of growth of 12 rings per inch is reached and then remains the same.

EFFECT OF WEIGHT.

Figure 5 shows the relation between weight and crushing strength for longleaf, shortleaf, and loblolly. In the case of loblolly and shortleaf the specimens were 2 by 2 inches in section and 8 inches long, while the longleaf specimens were 4 by 5 inches in section and 16 inches long. On account of this difference in size the part of the diagram relating to longleaf is not strictly comparable with that for the other two pines. The three lines serve to show, however, that the strength increases directly with the weight for all three pines. This diagram and many others for various species indicate that the dry weight is one of the best factors to use in judging the strength of wood. As summer wood is a good criterion of weight, it also becomes a means of judging the strength of timber.

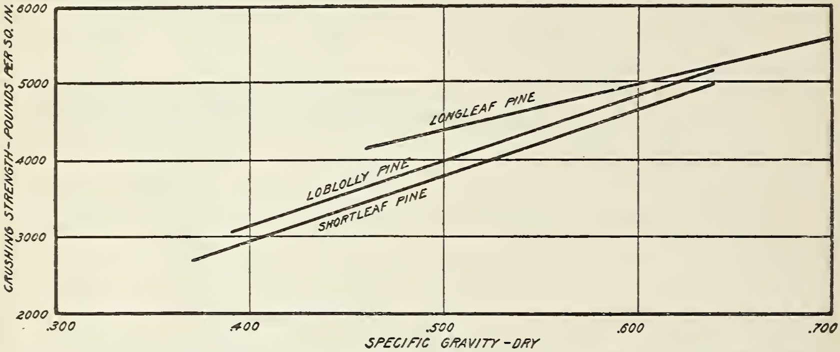

FIG. 5.—Relation between weight and crushing strength for longleaf, shortleaf, and loblolly pine. Longleaf: Number of tests, 43; size of specimens, 4 by 5 by 16 inches. Shortleaf: Number of tests, 263; size of specimens, 2 by 2 by 8 inches. Loblolly: Number of tests, 162; size of specimens, 2 by 2 by 4 inches.

EFFECT OF AGE AND HEIGHT IN TREE.

Since the interior of the butt log represents the young sapling of less than 15 or 20 years of age, it is generally comparatively light and weak. The heaviest wood in longleaf is found between the ages of 15 and 120 years. The wood formed after this age is lighter and consequently weaker. In the shorter-lived loblolly and shortleaf the period for the formation of the heaviest wood is between the ages of 15 and 80 years. The strength of sapwood depends upon the period of growth when it was formed. In large-sized trees the sapwood is weak. On the other hand, in comparatively young trees the sapwood is heavy and strong.

The wood in any one tree of longleaf, shortleaf, or loblolly is progressively lighter and weaker from the base to the top. The decrease in weight and strength is greatest in the first 20 feet from the stump and grows smaller upward. Figure 6 shows the variation of weight with height.

EFFECT OF "BOXING."

"Boxing" or "bleeding" longleaf pine trees is generally regarded as injurious to the timber both in respect to strength and durability. Specifications for structural material are sometimes drawn so as to exclude timber cut from trees which have been tapped for their resin.

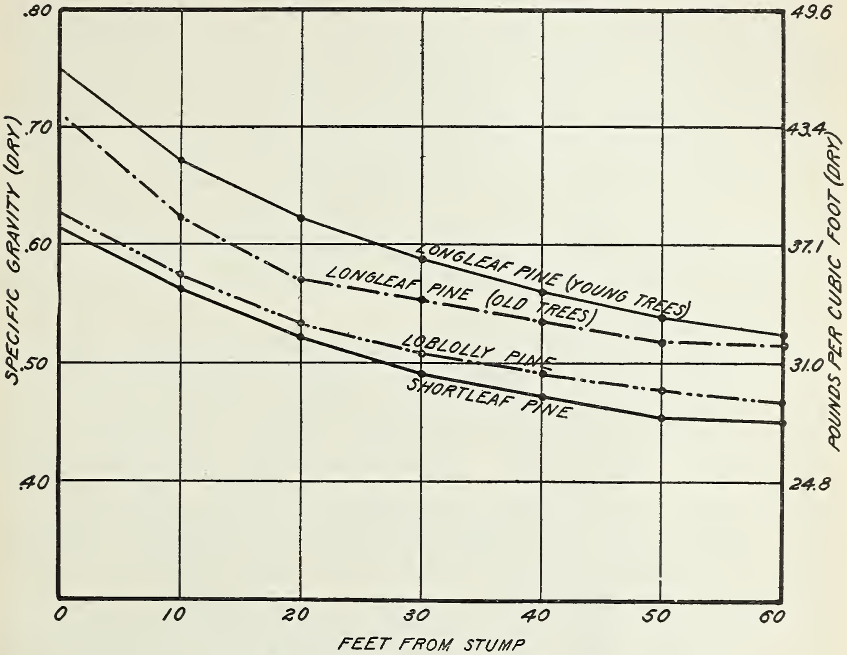

FIG. 6.—Variation of weight with height in tree.[a]

An investigation was made to determine the effect of "boxing" on the strength, weight, shrinkage, and durability of longleaf pine. Thoroughly seasoned material was used. The results of the mechanical tests are given in Table 11:

TABLE 11.—*Effect of "boxing" on the strength of longleaf pine.*[a]

	Number of tests.	Specific gravity (dry) of test pieces.	Modulus of rupture.	Crushing strength parallel to grain.
			Pounds per square inch.	*Pounds per square inch.*
Longleaf pine:				
Unboxed trees	400	0.74	12,358	7,166
Boxed and recently abandoned	390	.79	12,961	7,813
Boxed and abandoned five years	535	.76	12,586	7,575

[a] Taken from Circular 12, Division of Forestry.

The investigation shows (1) that bled timber is as strong as unbled if of the same weight, (2) that the weight and shrinkage of the heartwood are not affected by boxing, and (3) that the durability of the heartwood is not affected by "boxing" since the gum comes from the sapwood only.

UTILIZATION.

For the past fifteen years the southern pines have furnished the larger part of the timber for building purposes in the United States.

Longleaf pine is unsurpassed as a structural timber, and finds a wide use in bridge, trestle, warehouse, and factory construction in the form of dimension timbers, posts, piles, and joists. It makes an excellent material for spars and masts, large quantities being exported to England for such use. In the building of railroad cars longleaf is largely used on account of its strength and stiffness. It is also employed to a large extent for flooring on account of its hardness and wearing qualities.

Shortleaf and loblolly are used principally for building lumber, such as interior finish, flooring, ceiling, frames and sashes, wainscoting, weatherboarding, joists, lath, and shingles; for boxes and packages, in the form of boards and veneers, and in cooperage for the manufacture of slack barrels. These pines are also used in the manufacture of cheap furniture, woodenware, toys, etc. The wood of shortleaf pine is especially fitted to the work of the house carpenter, because of its comparative freedom from resinous matter, its stiffness, and its ease of working.

Shortleaf and loblolly are also used for construction purposes, in bridge and trestle work, and heavy building operations where the conditions are not such as to require longleaf. The recent introduction of preservative processes, by which the timber under treatment is impregnated to a certain depth with an antiseptic liquid, usually creosote oil, which prevents or retards decay, has increased the use of shortleaf and loblolly for structural purposes. The wood of both of these pines is of such a character as to be easily treated with preservatives, especially in the case of the sapwood. Longleaf, on the other hand, because of its greater density, higher per cent of resinous matter, and smaller per cent of sapwood, is difficult to treat satisfactorily with a preservative, except in the case of small blocks such as are used for street paving. Longleaf furnishes a very satisfactory material for this purpose, and in the United States is used in the majority of cases where wood is employed as a paving material. If used in exposed places in an untreated condition, shortleaf and loblolly are not durable on account of their large proportion of sapwood, which in its natural state decays rapidly. The heartwood of longleaf, while noted for its durability when exposed to the action of the weather, in comparison with other woods in an untreated condition, will not last as long as treated shortleaf and loblolly. Until a few years ago the manufacturers of southern pine lumber were handicapped on account of the tendency of moist sapwood boards to turn blue, due to the rapid development of a fungous growth. Since the introduction of kiln-drying at the mills, this tendency to "blue" has been overcome and the durability and finishing qualities of the material increased.

During 1906 southern pines furnished nearly 19 million railroad ties, about one-sixth of the total number used in the United States. A considerable portion of these ties was treated with either creosote oil or zinc chloride. The average life of the untreated sap tie is about three years, while that of a properly treated sap tie is about fifteen years. Southern pine telegraph poles are used to some extent, but are not nearly so satisfactory for this purpose as cedar or chestnut, unless previously treated, because their sapwood decays very rapidly. Loblolly and shortleaf are used to a large extent in mining operations as both round and sawed timber. The conditions in mines are such as to cause timber to decay very rapidly. Preservative processes have recently been applied to mine timbers, and although not extensively used at the present time, have apparently been satisfactory wherever tried.

The resinous product obtained by boxing longleaf pine furnishes the raw material from which turpentine and resin are made. The bulk of the naval stores used in the world comes from the southern longleaf pine forests, and the production of these stores is one of the most important industries connected with forest products. In the boxing process the bark at the base of the tree is removed in one or more places and the sapwood gashed. The resin flows from the wounds and is collected and distilled.

Very often a planing mill is combined with the sawmill, so that material can be shipped as flooring, finish, siding, etc., instead of as rough lumber, thereby effecting a saving in freight charges. Shingles and lath mills and box factories are also sometimes operated in conjunction with the sawmill, and in this way considerable material is utilized which would otherwise be wasted on account of its small size. Part of the waste from the sawmill is utilized under the boilers and the rest generally burned in the refuse burner or thrown away. Of late, attempts have been made to make use of this refuse by subjecting it to a process of distillation. In one process the waste is first cut into small chips which are brought into contact with steam. The steam extracts from the chips such products as wood turpentine and "pine oil," and carries them in the form of vapor to the condenser, where they are collected in liquid form. In another process the stumps of the southern pines, which are rich in resinous material, are collected and heated in closed retorts, the resulting vapors being condensed and recovered. Wood turpentine, tar, and tar oils are obtained by this process with a residue of charcoal. The yield of merchantable products for the same amount of material is greater from stump wood than from the ordinary run of mill waste.

Many of the mills manufacturing southern pine lumber are located near the coast, where their wharves are directly accessible to lumber schooners and oftentimes can be reached by ocean steamers. In this way a large amount of lumber is shipped to the northern markets and also abroad. The inland mills ship north or west by rail, or to the nearest coast shipping point for foreign trade. The principal northern coast markets, such as Baltimore, Philadelphia, and New York, are supplied with southern pine rough lumber almost entirely by cargo shipments from Norfolk, Charleston, Savannah, Jacksonville, Pensacola, Mobile, and New Orleans. Dressed stock is all shipped by rail, and the railroads supply all southern pine lumber to the large northern inland markets, such as Chicago, Buffalo, Cincinnati, Pittsburg, St. Louis, and Kansas City. These shipments are collected from various points convenient to localities where mills happen to be operating. Port Arthur and Galveston are also important lumber markets, but most of their shipments are to foreign countries, as these ports are too far from the northern coast markets to compete successfully for the domestic trade.

Approved:
James Wilson,
Secretary of Agriculture.

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